Technical Report 1347

Assessing Threat Detection Scenarios through Hypothesis Generation and Testing

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14. ABSTRACT *(Maximum 200 words)*: The purpose of this research was to explore the decision-making processes of Soldiers with different levels of experience as they evaluated scenarios with varying levels of uncertainty. This research focused on understanding the interaction of experience and uncertainty on hypothesis generation and testing, and on the relationship between confidence and decision-making. Soldiers engaged in computer-based exercises that measured decision-making performance in a threat detection task. These exercises involved reading threat-relevant scenarios and then reporting threat decisions. We gained a better understanding as to how Soldiers select and integrate cues in uncertain decision environments involving potential threats by having them complete such exercises. Findings indicated that experienced and inexperienced Soldiers tended to focus on different priority threats (or what they perceived as the most important threats). Experienced Soldiers were likely to report more discrete threats when identifying their priority threat in each scenario. They were also more likely to search information that confirmed their initial hypotheses. Overall, changes in hypotheses appeared to be associated with lower initial confidence ratings. Across experience levels, Soldiers tended to search relevant details more often than irrelevant details. Those findings provide insight into the cognitive processes Soldiers with varying levels of experience use to make threat decisions in certain and uncertain environments.

15. SUBJECT TERMS
Threat detection, Decision-making, Hypothesis generation, Hypothesis testing, Infantry, Irregular warfare, Asymmetric warfare, Attention

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ASSESSING THREAT DETECTION SCENARIOS THROUGH HYPOTHESIS GENERATION AND TESTING

EXECUTIVE SUMMARY

Research Requirement:

The operational environment often introduces severe time limitations and high uncertainty, requiring Soldiers to make immediate decisions about potential threats in high-risk and high-stakes situations. The overarching goal of this research was to explore the decision-making processes of Soldiers with different levels of experience as they evaluated scenarios of varying levels of uncertainty. This research was particularly focused on understanding the interaction of experience and uncertainty on hypothesis generation and testing and on the relationship between confidence and decision-making. In order to achieve the research focus, the experiment we conducted allowed us to clarify how Soldiers generate and test hypotheses by selecting and integrating cues in uncertain decision environments involving potential threats. Specific research questions investigated whether experienced and inexperienced Soldiers differed in the priority threats they identified in a given scenario, their confidence in their initial assessments, the number and type of cues they used to make judgments, and the adjustments made to their hypotheses after seeking additional information.

Procedure:

Fifty-nine Soldiers engaged in computer-based exercises that measured decision-making performance in a threat detection task. The exercises involved reading threat-relevant scenarios and then reporting threat decisions. Each Soldier read two certain and two uncertain scenarios. After reading each scenario, Soldiers performed a threat assessment by identifying the highest priority threat and explaining the importance of this threat. They then rated their confidence in their initial assessments and described the cues and information they used to make their decisions. After each threat assessment, Soldiers described their course of action (COA) and provided a confidence rating for how successful this COA would be at mitigating the identified threat. Soldiers could then gather more information about each scenario from six topics. After reviewing additional information, Soldiers had the opportunity to revise their original threat assessment. They also provided alternative explanations for each scenario and alternative action choices.

Findings:

Experienced and inexperienced Soldiers focused on different priority threats across three of the four scenarios, though their overall patterns of responding did not differ. That might indicate that Soldiers who previously deployed, and went outside the wire, attend to different cues in the environment and possibly process these cues differently. Experienced Soldiers were likely to report more discrete threats when identifying their priority threat in each scenario. They were also more likely to search information that confirmed their initial hypotheses. Both experienced and inexperienced Soldiers tended to report relatively high confidence in their initial threat decisions. Changes in hypotheses appeared to be associated with lower initial confidence

ratings. That indicates that Soldiers may have been relatively well calibrated. Experienced and inexperienced Soldiers did not differ on other measures, such as the variability in their priority threats, the number of cues identified as informative, and whether they searched relevant additional information topics. Perhaps these results reflect the constraint imposed by the testing materials, such as a limited number of cues available to inform the initial hypothesis; however, they may also reflect general trends in cognition. Across experience levels, Soldiers tended to search relevant details more often than irrelevant details.

Utilization and Dissemination of Findings:

Overall, this experiment supports the idea that differences exist between novice (inexperienced) and expert (experienced) Soldiers' decision-making processes, particularly in operationally relevant domains. The finding that Soldier's initial confidence seemed to be associated with their inclination to change their hypotheses is promising, particularly if they are inclined to evaluate and revise hypotheses when they are not maximally confident. Whether or not Soldiers changed their initial hypotheses is a reasonable measure of how plausible they thought their hypotheses were, even after the opportunity to evaluate them critically. Across scenarios, there was little difference between experienced and inexperienced Soldiers in identifying informative cues. That finding comports with literature that suggests decision makers generate hypotheses using relatively small sets of data (e.g., Klein, 1998). Future research should conduct testing in naturalistic environments to gain a greater understanding of Soldier decision-making processes. Using a more naturalistic environment might mitigate limitations of memory inherent in computer-based tests, where participants only passively experience the scenario through text rather than a comprehensive experience (e.g., via live scenarios).

ASSESSING THREAT DETECTION SCENARIOS THROUGH HYPOTHESIS GENERATION AND TESTING

CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

ASSESSING THREAT DETECTION SCENARIOS THROUGH HYPOTHESIS GENERATION AND TESTING

Decision makers must engage in several cognitive processes prior to taking action, including perceiving and processing situational cues and then generating, evaluating (or implicitly testing), and revising hypotheses as necessary. These processes rely on a complex interaction of factors, including background knowledge, situational cues, environmental factors, and the cognitive resources necessary to perceive and evaluate this incoming information. A critical decision Soldiers must often make in operational environments is whether (and to what extent) a situation poses a threat. That decision guides how Soldiers determine and implement courses of action. When evaluated collectively, cues provide a holistic representation of events that guide how decision makers perceive, interpret, and act upon situations. Soldiers attempting to detect threats and make what are sometimes life-saving decisions, must operate in environments that present ambiguous, missing, or continually changing threat cues. These instances can lead to uncertainty about the situation and the action to take.

Uncertainty forces decision makers to either delay a decision in an effort to reduce uncertainty or forego uncertainty-reducing processes and make an immediate decision based on the available information (even if incomplete and/or biased). Both actions have advantages and disadvantages, and they will be more or less likely to occur, depending upon the cost of delaying a decision (Cohen, Freeman, & Thompson, 1998). If the cost of delaying a decision is unacceptable (e.g., the severity of a potential threat increases over time), the decision maker makes an immediate decision, even if the outcome is suboptimal. If the cost of delaying a decision is acceptable, the decision maker will attempt to reduce uncertainty by seeking more information and increasing the odds of making an optimal decision. The operational environment often introduces severe limitations on time, requiring Soldiers to make immediate decisions about potential threats even in the face of uncertainty. Making decisions in these high-risk, and high-stakes, situations requires complex cognitive processing. A goal of this research was to elucidate some of the judgment and decision-making processes (i.e., hypothesis generation and evaluation) inherent in conditions marked by uncertainty, specifically when detecting threats.

Osman (2010) reported that novices and experts differed in how they processed information in uncertain environments (see also Lipshitz & Strauss, 1997). Experienced Soldiers may quickly recognize and interpret critical cues that help them interpret the decision environment and formulate hypotheses, whereas inexperienced Soldiers may need to seek more information before developing a hypothesis and then making sense of the situation. In addition, experienced decision makers tend to take into account novel information and adjust their assessments to account for this information. Experienced decision makers tend to be more fluid than novices are when adapting their current assessments of the situation to account for novel or anomalous information (Dreyfus & Dreyfus, 1986; Ross, Phillips, Klein, & Cohn, 2005). Another goal of this research was to explore Soldier decision-making at different levels of experience and uncertainty. We predicted that Soldiers with more experience would have a greater proficiency for detecting and reasoning about threats. These proficiencies allow decision makers to generate and test hypotheses about uncertain decision environments.

The following research explores the decision-making processes of Soldiers with different levels of experience as they evaluate scenarios with differing levels of uncertainty. This experiment focuses on understanding the interaction of experience and uncertainty on hypothesis generation and testing and on the relationship between confidence and decision making. As a result, we attempted to gain a better understanding as to how Soldiers generate and test hypotheses by selecting and integrating (informational) cues in uncertain decision environments involving potential threats. Specific research questions investigated whether experienced and inexperienced Soldiers differed in the:

- Priority of threats they identify in a given scenario;
- Confidence they have in their initial assessment of the scenario;
- Number of cues they identify to support their initial hypotheses (threat decisions);
- Extent to which they seek information that confirms their initial hypotheses; and,
    - Additional information;
    - Relevant versus irrelevant information; and,
- Adjustments to their hypotheses after seeking additional information.

In the current experiment, we manipulated the certainty of decision contexts to measure the extent to which Soldiers of varying experience levels appear to engage in verbatim versus gist processing across different threat situations. We examined the number of cues used by both experienced and inexperienced Soldiers across different conditions of uncertainty and expected that experienced Soldiers would identify fewer cues relative to inexperienced Soldiers and that they would form a more comprehensive view of the environment.

Hypothesis Generation

When decision makers generate hypotheses, they create potential explanations given a set of information (Fisher, Gettys, Manning, Mehle, & Baca, 1983; Gettys & Fisher, 1979). Across a variety of decision contexts, decision makers tend to generate hypotheses naturally (Thomas, Dougherty, Sprenger, & Harbison, 2008). Hypothesis generation typically includes creating explanations that inform the evaluation and testing of any one potential solution or course of action. For example, in recognition-based decision models (e.g., the Recognition-Primed Decision model; Klein, 1997), experienced decision makers identify critical cues in the environment and match these cues to details in memory of previously experienced situations. From this match, decision makers can quickly recognize the situation, develop a hypothesis, and predict an outcome. Research tends to show that expert decision-making in uncertain environments relies heavily on pattern matching. Cohen, Freeman, and Wolf (1996) reported that features of the decision problem activates related schemas through recognitional pattern matching. As decision makers gain experience, more patterns are stored in memory, which enables decision makers to more quickly recognize and respond to situations (see also Klein, 1993; Klein, 1997; Lipshitz & Strauss, 1997). However, when the environmental cues do not match the event features in memory, recognition does not occur immediately. In those cases, experienced decision makers will generate alternative hypotheses in an attempt to achieve a recognitional match to existing schemas. In contrast, less experienced decision makers lack a comprehensive store of relevant events in memory and thus have difficulty matching

environmental cues. They instead generate multiple possibilities informed by a wider range of available cues.

The observed differences between expert and novice hypothesis generation processes may be due to the nature of the decisions examined (or the tasks performed; e.g., see Norman, Brooks, & Allen, 1989). Norman et al. contrasted the task of playing chess with that of diagnosing medical conditions. Whereas both chess players and physicians must recognize patterns among a fixed set of cues, physicians in high-stakes environments must also be able to evaluate a potentially unlimited number of novel cues and search for additional cues, all while maintaining these details in memory. Thus, the common research finding that chess experts can hold and process more information chunks in memory than can novices (e.g., Chase & Simon, 1973) does not necessarily generalize to expert physicians (e.g., see Patel, Arocha, & Kaufman, 1994). Similar to the demanding task of medical diagnosis, detecting threats is highly complex and, when embedded in dynamic contexts, likely requires decision processes that change along with the situation. For example, a situation that matches previous experience and allows for some certainty will likely provoke a quick hypothesis generation process. By contrast, a situation that fails to match previous experience and causes uncertainty, will likely lead to a slower, more deliberate hypothesis generation process.

Regardless of the model or theory enlisted to explain hypothesis generation (e.g., see Cohen et al., 1998; Klein, 1998; Reyna, Lloyd, & Brainerd, 2003) the role of memory appears to be a critical component (e.g., see Gettys, Manning, Mehle, & Fisher, 1980). Details in the decision environment serve as retrieval cues that likely differ across contexts. It is unclear how many cues decision makers typically use to construct hypotheses, though some researchers argue that experienced decision makers use only a small number of cues to produce decisions (e.g., Klein, 1998). Regardless of the number of cues evaluated, research also shows that experts focus on more informative or applicable cues relative to novices (Shanteau, 1992).

One theory that explains differences in the number of cues decision makers use to form a hypothesis is the fuzzy trace theory (Reyna et al., 2003). This theory assumes that two forms of processing work to form a hypothesis: verbatim and gist processing. Verbatim processing entails evaluating all of the cues in a decision environment. For example, a Soldier may attend to the area of interest, for instance, an area of disturbed earth. They will also evaluate the undisturbed earth around the area, a nearby wall, vehicles in the immediate vicinity, the distance to the nearest dwelling, the time of day, fresh tire tracks, and other cues to generate an understanding of the environment and to determine the threat relevance of the disturbed earth. Reyna and colleagues suggested that novices use a large number of details, such as these, to generate a hypothesis about the decision environment. By contrast, experts tend to engage in gist processing, in which they attend to relatively few, but critical cues to generate a holistic representation of the decision environment (see also Werner and Thies, 2000, for a discussion of domain-specific influence on cue utilization). For example, to generate a rough understanding of the environment and its threat relevance, an experienced Soldier may attend only to the area of disturbed earth, the distance to the nearest dwelling, and local traffic patterns.

Hypothesis Testing

When decision makers engage in hypothesis testing, they check the explanations they formed to account for the decision environment. As with hypothesis generation, multiple theories and models exist to characterize and explain hypothesis testing (e.g., Cohen et al., 1996; Klein, Moon, & Hoffman, 2006; Osman, 2010). Unlike hypothesis generation, however, researchers often consider testing to be a deliberative cognitive process. For example, Cohen et al. suggested that decision makers engage a set of serial processes to evaluate the accuracy of their hypotheses under conditions of uncertainty. They evaluate their hypotheses to determine completeness (Is there sufficient support for the decision?), potential conflict (Are two incompatible outcomes supported?), and reliability (Is the cue-to-outcome relationship supported by examined vs. unexamined assumptions?). If their testing reveals flaws, decision makers will attempt to correct the hypothesis by gathering more information or re-considering information. When additional information corrects the flaw, for instance by filling in gaps in knowledge, resolving cue-outcome conflicts, or confirming/denying assumptions, the decision maker adjusts the hypothesis and re-tests it.

Under conditions of certainty, initial hypotheses tend to be complete, compatible with outcomes, and reliable. Further evaluation and information seeking is unnecessary and inefficient in such cases, thus decision makers take action based on the expected outcomes of the hypotheses. Cohen et al. (1996) recognized that the perceived cost of hypothesis testing influences the willingness of decision makers to engage in deliberative processing. If the cost of hypothesis testing appears too high, or the resources required for testing are unavailable, then a decision may occur quickly, but at the risk of being only partially informed and unreliable. The operational environment may regularly produce situations in which the costs of effortful hypothesis testing are too high, and thus decision makers must make quick decisions without additional testing. In the present experiment, we examined the influence of uncertainty and experience on hypothesis generation and testing when the cost of testing was salient. Specifically, we assigned costs to each information search that Soldiers engaged in after they formulated their initial hypothesis. Because experienced decision makers can draw on previous experiences, there are lower risks associated with taking action without further testing and a reduced sense of uncertainty. Thus, we expected that in conditions of uncertainty experienced Soldiers would seek fewer pieces of additional information compared to inexperienced Soldiers. Conversely, under conditions of certainty, experienced and inexperienced Soldiers would seek additional information at the same rate.

In addition to examining the amount of information Soldiers gathered to test hypotheses, we compared the type of information experienced and inexperienced Soldiers chose to consider when testing their hypotheses. Shanteau (1992) suggested that expert decision makers are better able to differentiate between relevant and irrelevant information. However, he identified several domains in which expert decision makers performed no better than did novice decision makers. Further, Raab and Johnson (2007) noted differences in the generation of options and strategy selection based on level of expertise. The current experiment examined the influence of uncertainty and experience on the relevance of the information Soldiers sought to test hypotheses. We forced decision makers to choose at least one piece of additional information from a set of information topics that included both relevant and irrelevant details, after they had

indicated their initial hypotheses. We expected that experienced Soldiers would choose relevant details more often than irrelevant details and inexperienced Soldiers would choose relevant and irrelevant details equally. We also predicted an interaction between experience and uncertainty. We expected that in the uncertain condition, experienced Soldiers and inexperienced Soldiers would differ in selecting relevant versus irrelevant details, whereas under conditions of certainty, experienced Soldiers and inexperienced Soldiers would not differ in selecting relevant details.

Forcing decision makers to choose at least one piece of additional information allowed us to explore the extent to which Soldiers demonstrate confirmation bias by choosing information that served to confirm their initial hypothesis. Confirmation bias is one of the most common decision biases, in which decision makers search for information or make interpretations that confirm their pre-existing beliefs. By doing this, they may sometimes ignore or dismiss other important information, leading to errors in judgment. Researchers have generally found that decision makers prefer to take steps toward confirming rather than disconfirming their hypotheses. For example, Adsit and London (1997) found that participants generally sought to confirm the hypotheses they generated. When experimenters provided the hypotheses, participants produced more disconfirmations than they did when they generated their own hypotheses or when they received hypotheses generated by other participants. Soldiers in the present experiment generated and tested their own hypotheses, thus we expected that they would seek out information to confirm their hypotheses. Furthermore, we expected that displays of confirmation bias would be associated with greater confidence in their initial hypothesis.

In addition to confirmation bias, measures of confidence ordinarily allow for examinations of calibration (for a review, see Griffin & Brenner, 2008). Typically, subjective probabilities of accuracy (confidence) that align with similar objective probabilities of accuracy (actual accuracy) indicate good calibration. By contrast, misaligned probabilities indicate poor calibration. In this experiment, there were no objective measures of accuracy because no real (experienced) threats existed in the scenarios (thus, there was no objective, correct answer). To assess calibration in this context, we measured the association between confidence and accuracy by examining changes in hypotheses at different levels of initial confidence.[1] If high-confidence hypotheses change over time, then we might reasonably assume that calibration was less than optimal. By contrast, changes in low-confidence hypotheses likely reflect better calibration.

Experiment

Method

Design. Experienced and inexperienced Soldiers each completed four decision-making scenarios, each of which included the same set of eight questions (see Appendix A). The level of threat varied across the scenarios with two scenarios presenting relatively clear, unambiguous threats and two scenarios presenting ambiguous threats intended to increase uncertainty. Presented along with each scenario were six additional, searchable information topics that were either relevant to the threat scenario or irrelevant. Soldiers were required to search one topic and could search up to six topics per scenario. This experiment used a mixed design, with contextual

[1] Unchanged hypotheses would be difficult to interpret in this context, as despite being stable they may also be inaccurate.

cues (certain vs. uncertain) as a within-subjects factor and Soldier experience as a between-subjects fixed factor. Dependent measures were:

- Initial threat decision (i.e., identification of the highest priority threat);
- Confidence in initial threat decision;
- The number of cues that informed the initial threat decision;
- The number of searchable information topics explored;
- The proportion of relevant to irrelevant details explored; and,
- Changes to the initial threat decision.

Participants. Fifty-nine Soldiers participated in this research. Their mean age was 23 years (*SD* = 4.7). These Soldiers had paygrades ranging from E-1 to E-6 (see Table 1). Their mean time-in-service was 2.8 years (*SD* = 3.0). Thirty-four Soldiers (58%) deployed previously. We categorized those Soldiers as experienced as they had increased likelihood of carrying out threat detection on actual patrols as opposed to those who had not deployed. To clarify the 'experienced' categorization, we further asked deployed Soldiers how often they went "outside the wire." Of the Soldiers who previously deployed, 6% reported never going outside the wire, 3% reported going outside the wire less than once per month, 3% reported going outside the wire once per month, 85% reported going outside the wire more than once per month, and 3% reported going outside the wire once per day.[2]

Experience Grouping Variable. We operationalized experience (experienced vs. inexperienced) based on deployments. Experienced Soldiers had at least one prior deployment while inexperienced Soldiers had zero deployments. Thirty-five Soldiers reported at least one deployment. Of these, 24 were deployed once, and 11 were deployed more than once. The maximum number of deployments reported was five (*M* = 1.46, *SD* = .85).

Scenarios. Scenarios were developed based on contemporary experiences of active duty Soldiers and follow from data collected from previous research completed involving Soldiers' experiences conducting threat detection in operational settings (Zimmerman, Mueller, Grover, & Vowels, 2014). Each scenario included a short description of a military tactical threat situation. Two scenarios provided concrete information about potential threats (e.g., a statement indicating that bomb sniffing dogs kept returning to a specific location); this allowed for more certainty in assessment and decisions (see "Dog Day" and "The Rock" in Appendix A). Two scenarios presented more uncertainty by providing only ambiguous information about potential threats (e.g., a statement indicating that some local nationals are interested in inciting violence, but that local elders do not condone it; see "Checkpoint" and "Election" in Appendix A). After reading each scenario, Soldiers answered two questions (each with two sub-questions) about the potential threats in the scenario. Following these questions, Soldiers could search additional information to gain a better understanding of the situation (see the bolded labels on pg A-2). They could select information by choosing from among six searchable topics, three of which were relevant to potential threats in the scenario and three of which were irrelevant to potential threats. Relevant searchable topics contained information that could assist in identifying a priority threat,

[2] We specifically examined the 12% of Soldiers who reported going outside the wire once per month or less and found no statistically significant difference in our analyses whether we included them in the "inexperienced" or "experienced" groups.

whereas irrelevant topics provided information that was either arbitrary or did not offer useful intelligence. After searching through these topics, participants could review and revise their original assessment. Finally, they finished each scenario by answering two more questions about possible alternatives to their previous responses (see Appendix A for a full description of each scenario and the questions).

Table 1

Soldier Rank, Number Deployed, and Military Occupational Specialty (MOS)

Soldiers with Zero Deployments (n = 25)							
		MOS					
Rank	Total	11B	19K	68W	91F	92F	Other
Private	1						1
PV2	10	4	3	1	1		1
PFC	12	5	3	1	1		2
CPL/SPC	2			1	1		
SGT	0						
SSG	0						
Soldiers with One or More Deployments (n = 34)							
		MOS					
Rank	Total	11B	19K	68W	91F	92F	Other
Private	0						
PV2	0						
PFC	6	3	2			1	
CPL/SPC	19	5	5	1		2	6
SGT	8	3	2	1		1	1
SSG	1						1

Note: MOS are 11B = Infantryman, 19K = M1 Armor Crewman, 68W = Combat Medic, 91F = Small Arms/Artillery Repairer, 92F = Quartermaster Corps. Other includes 19D, 29E, 35F, 88M, 92A, and 92Y.

Manipulation Check. To ensure that the scenarios differed in the amount of certainty or uncertainty they afforded decision makers, they were evaluated by a small sample of experienced Soldiers (n = 5) and revised according to their feedback. Furthermore, during debriefing, a random subset of participants (n = 37) identified the scenario or scenarios they found to be notable and most difficult (vs. easy). Sixty-nine percent of the Soldiers who identified the scenarios with high certainty as notable (“Dog Day” and “The Rock”) indicated that those scenarios were the easiest. Sixty-seven percent of the Soldiers who identified the scenarios with high uncertainty as notable (“Checkpoint” and “Election”) indicated that those scenarios were the most difficult. Those differences were statistically significant, χ^2 (1, 37) = 4.56, p = .033[3].

To check the relevance of the searchable information, we examined the rates at which Soldiers searched/chose each type of information topic. Relevant details were searched

[3]This measure is indirect and subjective and, as such, should be used cautiously in subsequent analyses. For this reason, we did not collapse the scenarios into two groups (certain vs. uncertain) and instead kept them separated in subsequent analyses.

significantly more often than were irrelevant details (M = .80, SD = .45 vs. M = .50, SD = .38), $t(54) = 3.95$, $p < .001$, $d = .82$.

Computer-controlled stimuli presentation. The Psychology Experiment Building Language (PEBL; Mueller, 2009) program was used to control the computer exercises. Soldiers completed the experiment by viewing and responding to all stimuli and questions in this program. PEBL recorded all responses for later analysis.

Demographic questionnaire. Soldiers completed a demographic questionnaire as part of the computerized tasks. The questionnaire included questions about education, military experience, threat detection training, and specific field experience relevant to threat detection (Appendix B).

Procedure. Soldiers engaged in computer-based exercises that measured decision-making performance in a threat detection task. These exercises involved reading threat-relevant scenarios and then reporting threat decisions. Each Soldier read four scenarios (two certain and two uncertain). To account for any order effects, we counterbalanced the scenarios by programming PEBL to randomize the presentation order; no effects of order where found (p >.05). Soldiers completed a brief filler task (a paper-based word-find exercise) between scenarios to reduce potential interference from the previous scenario.

Soldiers who participated in the experiment signed informed consent forms, completed the demographic questionnaire, and began the scenario portion of the experiment. Soldiers were informed that they would read and listen (via headphones) to 10 threat scenarios on a computer. Before the Soldiers began the scenarios, a researcher gave them each a pencil and a notepad and told them that they could take notes during the scenarios, noting that the Soldier would not see the scenario details when it was time to respond to questions. The Soldiers received written instructions that following each scenario they would have the opportunity to search for information about that scenario; however, each information search would cost them virtual money. They were informed that they would begin with $200 and needed to ensure that they had enough money to complete all 10 scenarios (i.e., they should not spend all $200 on the first nine or fewer scenarios). Soldiers completed only four scenarios; to control for unnecessary search (spending too much of their resource too early) and to emphasize the importance of search, instructions indicated they would complete ten scenarios. Soldiers were debriefed as to the purpose of that manipulation at the end of the experiment. They were also informed that some scenarios would be more difficult than others, thus they should search through the additional information judiciously. After reading each scenario, Soldiers performed a threat assessment, identifying what they believed was the highest priority threat and explaining the importance of this threat. They then rated their confidence in their initial assessments and described the cues and information they used to make their decisions.

After each threat assessment, Soldiers described their COA and provided a confidence rating for how successful this COA would be at mitigating the identified threat. Soldiers could then gather more information about each scenario from six topics. Each information search cost $5 which was subtracted from their initial allocation of $200. They were required to search at least one topic, but had the option of selecting up to six pieces of information per scenario.

Soldiers could monitor their account via an onscreen account indicator. After reviewing additional information, Soldiers had the opportunity to revise their original threat assessment. They also provided alternative explanations for each scenario and alternative action choices.

Results and Discussion

Hypothesis generation: Identifying priority threats. We analyzed identified threats using Friedman's Rank Order test (Elliott & Woodward, 2007), which ranks items chosen most to least often. The results were graphed by scenario, showing rankings by experience level for each identified threat. Magnitude represents the relative frequency that Soldiers chose an item. In addition to analyzing the rank order of threats, we analyzed the overall pattern of responses across experience level using Bhattacharyya's distance equation for discrete probability distributions (e.g., see Choi & Lee, 2003). That equation quantifies the difference between two probability distributions, taking into account all possible responses. Distance values range from 0 to 1, with values closer to 0 indicating dissimilarity across distributions, and values closer to 1 indicating similarity across distributions. To conduct this analysis, priority threat data were normalized (the mean selection probability of each item was divided by the mean total responses for that item) to compensate for unequal sample sizes across experience groups.

Dog Day scenario. Both groups identified improvised explosive devices (IED) most often as a priority threat in the Dog Day scenario, but diverged with respect to the perceived importance of other threats; for example, the detainee's house was identified as a priority threat significantly more often by experienced versus inexperienced Soldiers, χ^2 (1, 59) = 5.98, p = .014 (Figure 1). The overall pattern of response between the two groups was similar, yielding a Bhattacharyya distance of .905.

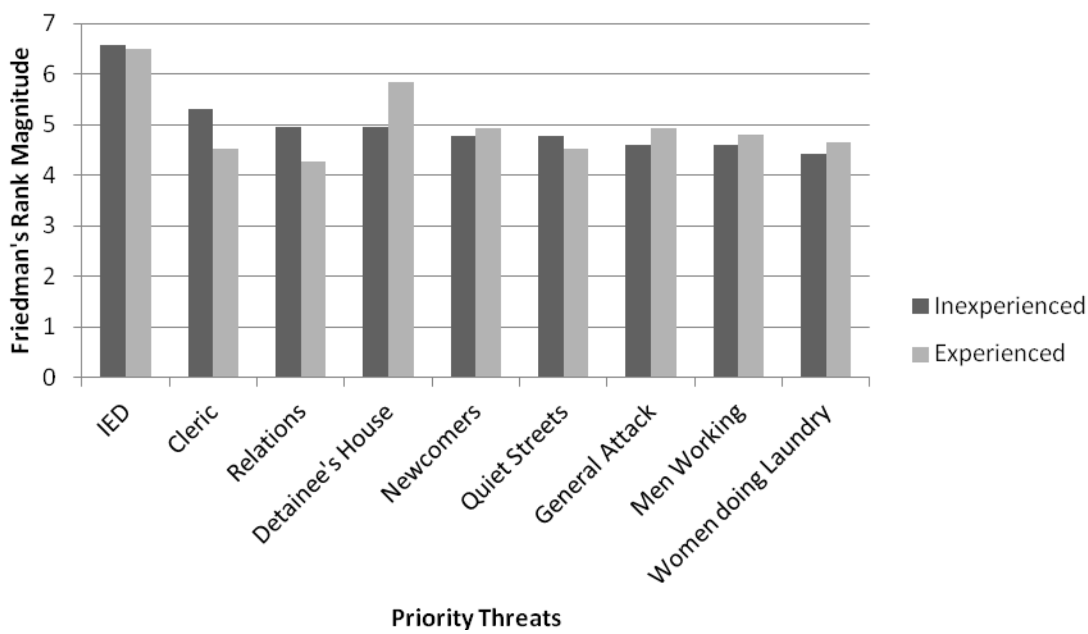

Figure 1. Rankings of priority threats identified in the Dog Day scenario.

The Rock scenario. Both experienced and inexperienced Soldiers identified spies most often as a priority threat. Experienced and inexperienced Soldiers differed most in identifying the leak of intelligence to potential insurgents (Intel) as a priority threat; however, this difference did not reach statistical significance, χ^2 (1, 59) = 3.30, p = .069 (Figure 2). The overall pattern of response between the two groups was similar, yielding a Bhattacharyya distance of .948.

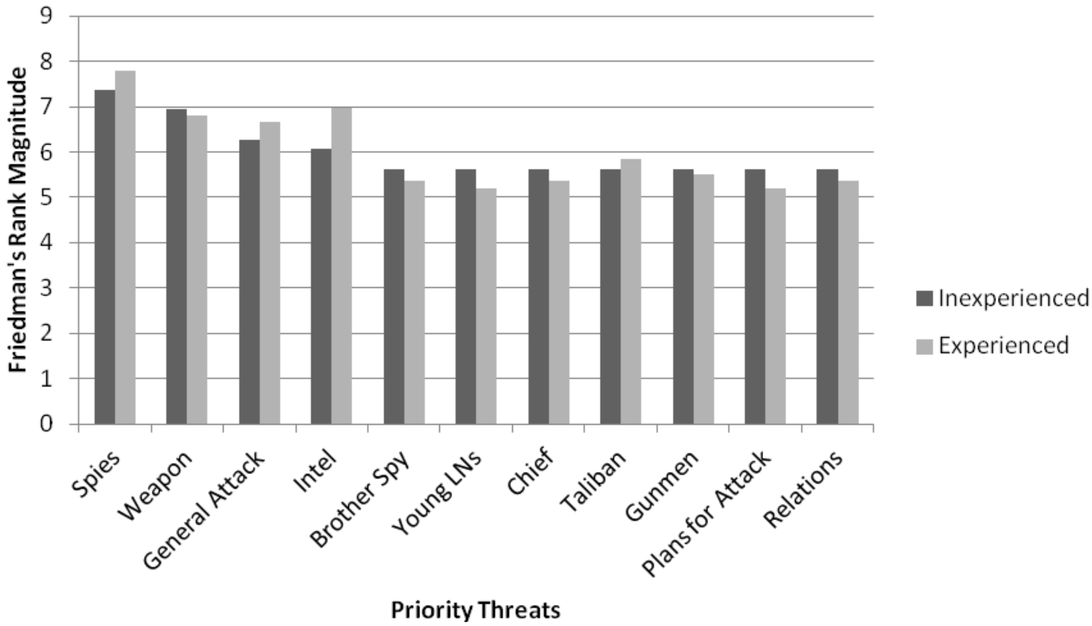

Figure 2. Rankings of priority threats identified in The Rock scenario.

Checkpoint scenario. In the Checkpoint scenario, both groups identified worsening relations between U.S. Forces and the host-nation populace as the priority threat relative to the other threats. There was also agreement between the groups about the next two threats in descending rank order: young local nationals and a breakdown in communications between U.S. leaders and local elders (Figure 3). Only one threat was identified differentially by experienced versus inexperienced Soldiers: Experienced Soldiers were more likely than inexperienced Soldiers to identify Intel as a priority threat, χ^2 (1, 59) = 4.02, p = .045. The overall pattern of response was similar between experienced and inexperienced Soldiers, yielding a Bhattacharyya distance of .852.

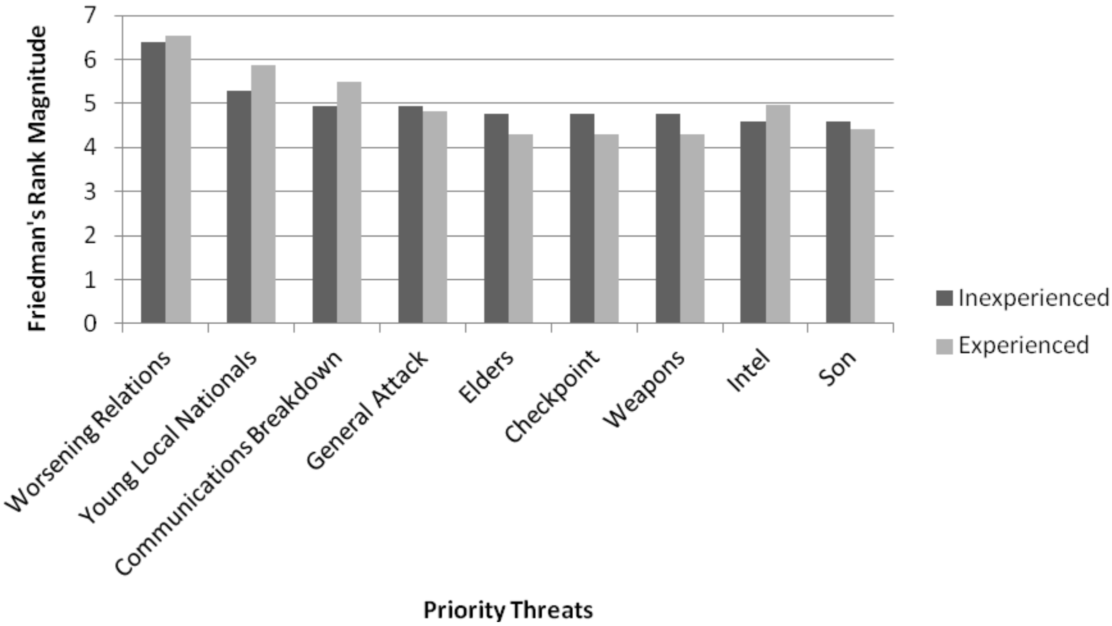

Figure 3. Rankings of priority threats for the Checkpoint scenario.

Election scenario. In the Election scenario, inexperienced and experienced Soldiers tended to select the vulnerability of the election headquarters as the priority threat. There was no group difference in the frequency with which this threat was identified as the priority, χ^2 (1, 59) = 0.215, p = .643. Experienced Soldiers also identified as a priority threat the uncertainty they had about selecting the election headquarters. Compared to inexperienced Soldiers, experienced Soldiers were more likely to identify this uncertainty as a priority threat, χ^2 (1, 59) = 4.25, p = .039. A related-samples McNemar test revealed that experienced Soldiers selected uncertainty and the election headquarters as the priority threat equally, χ^2 (1, 34) < .001, p = 1.00 (Figure 4). The overall pattern of response was similar between experienced and inexperienced Soldiers, yielding a Bhattacharyya distance of .940.

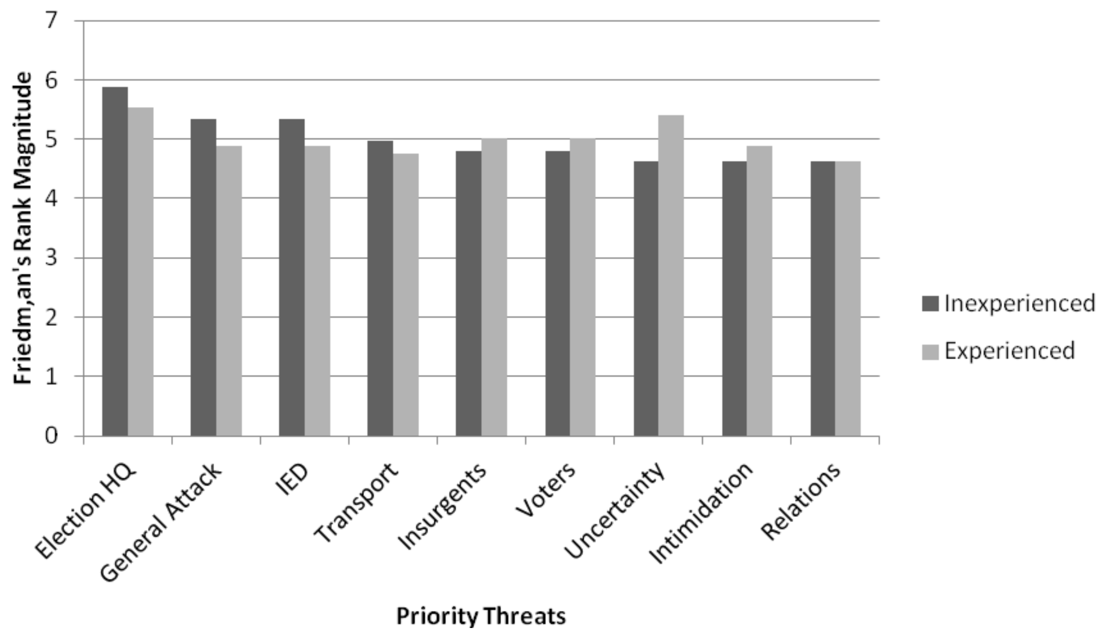

Figure 4. Rankings of priority threats identified in the Election scenario.

Cross-scenario analysis. Across scenarios, few differences in threat identification emerged between groups.[4] We did not observe the overall pattern of responding we expected. Experienced Soldiers did not identify smaller, more homogenous sets of cues than did inexperienced Soldiers. Instead, a repeated-measures analysis of variance (ANOVA) revealed that experienced Soldiers tended to report *more* priority threats across all scenarios (M = 6.32, SD = 1.70) than did inexperienced Soldiers (M = 4.32, SD = 1.38), $F(1, 57) = 4.83$, $p < .01$, *partial* $eta^2 = .291$. There was also a significant main effect of certainty for the number of threats reported. "Certain" scenarios (Dog Day and The Rock) yielded more priority threats (M = 3.08, SD = 1.29) than did "uncertain" scenarios (Checkpoint and Election; M = 2.38, SD = 1.02), $F(1, 57) = 12.76$, $p = .001$, *partial* $eta^2 = .183$, but there was no significant interaction between levels of certainty and experience, $F(1, 57) = 1.94$, $p = .17$, *partial* $eta^2 = .033$.

One explanation for why the certain scenarios yielded more priority threat identifications is that the information presented in those scenarios was more concrete, thus more memorable over time (e.g., Walker & Hulme, 1999). By contrast, the uncertain scenarios offered less clarity and concreteness; thus, the Soldiers may have forgotten the somewhat ambiguous threats in these scenarios before they recorded their priority threat responses. If identifying priority threats was in part contingent upon working memory (e.g., Thomas, Dougherty, Sprenger, & Harbison, 2008), then we would expect to see better memory performance and thus, more threats identified, by experienced Soldiers, who might have an increased (or more efficient use of) working memory capacity for the threat detection domain. The results supporting this notion showed that experienced Soldiers did identify more threats than did inexperienced Soldiers. Overall, inexperienced Soldiers reported more than one threat in only 21% of scenarios, whereas

[4] When compared to a conservatively corrected alpha for per-experiment comparisons (e.g., Bonferroni-corrected alphas between .005-.006), no differences across groups on individual threat selection reached statistical significance, no $p < .014$.

experienced Soldiers reported more than one threat in 45% of scenarios. This result could indicate that experienced Soldiers possess comprehensive schemas, increasing their ability to recognize and recall more threat possibilities among the scenarios. In contrast, inexperienced Soldiers with relatively fewer, less developed schemas would not have the same access to memory and thus, would identify fewer threats. We would also expect uncertain scenarios to have little impact on experienced Soldiers' memory, thus they should remember similar numbers of threats regardless of certainty level. However, we found no interaction between certainty and experience, indicating that both groups of Soldiers similarly reported fewer threats in the uncertain scenarios. A possible explanation for this finding is that the uncertain scenarios in this experiment were sufficiently ambiguous and difficult enough to affect both experienced and inexperienced Soldiers similarly.

Hypothesis generation: Cues identified as supporting priority threat decision. Experienced Soldiers tended to identify more cues across scenarios than did inexperienced Soldiers (Table 2); however, this difference was not statistically significant across all scenarios, $t(57) = 1.58$, $p = .12$. The difference between experienced and inexperienced Soldiers reached statistical significance in only the Election scenario, $t(56.75) = 2.21$, $p = .03$, $d = .54$. As can be seen in Table 2, the range of mean differences across scenarios is quite small. It is unclear what these differences might mean for threat decisions in the real world. That is, the effect of considering two versus three critical cues when making a decision is difficult to determine from these results. These results do support the notion that decision makers tend to rely on very few cues when generating their hypotheses (e.g., Klein 1998). The maximum number of cues identified in any scenario was five. This occurred only in the Dog Day scenario, and only 16% of all Soldiers identified more than three cues in this scenario. In all other scenarios, the maximum number of cues identified was three, with fewer than 20% of all Soldiers identifying three cues in any of these remaining scenarios.

Table 2

Mean Number of Cues Identified Per Scenario

	Experience Level						
	Inexperienced		Experienced				
Scenario	Mean	SD	Mean	SD	Mean Difference	*p*	Effect Size
Dog Day	2.3	1.27	2.5	1.01	0.2	.48	$d = .17$
The Rock	1.6	0.57	1.7	0.76	0.1	.59	$d = .15$
Checkpoint	1.7	0.67	1.8	0.74	0.1	.29	$d = .14$
Election	1.2	0.44	1.5	0.06	0.3	.03	$d = .54$*
Across Scenarios	1.7	0.74	1.9	0.79	0.175		

*****_Denotes an effect size found to be statistically significant at alpha = .05; however, this effect fails to meet statistical significance at the Bonferroni-corrected alpha of .0125 (correcting for four planned comparisons)._

Examining the mean number of cues identified within levels of certainty (i.e., “Dog Day” and “The Rock” vs. “Checkpoint” and “Election”) yielded a significant main effect of certainty. More cues were identified across the certain scenarios (M = 2.03, SD = 0.69) than across the uncertain scenarios (M = 1.58, SD = 0.50), $t(58) = 5.09$, $p < .01$, $d = .75$. There was no interaction of experience and scenario on the number of cues identified, at either the collapsed level, $F(1, 57) = 0.31$, $p = .58$, *partial* $eta^2 = .005$, or treating each scenario independently, Greenhouse-Geisser corrected $F(2.43, 138.54) = .199$, $p = .86$, *partial* $eta^2 = .008$.

Experienced and inexperienced Soldiers performed similarly across scenarios perhaps because the scenarios offered a finite set of cues to which they could attend. In contrast, real-world threat decision environments likely offer nearly countless cues that can inform threat decisions. Thus, we might expect to find a greater number and diversity of cues identified in more naturalistic decision-making environments. As noted, memory appears to play a critical role in hypothesis generation. Perhaps decision makers attend only to what they can maintain in working memory (e.g., see Thomas, et al., 2008). In the case of the experimental scenarios, we removed the critical information and the scenario context before Soldiers identified the cues they relied on to choose a priority threat.[5] Similar to priority threat selection, perhaps the number of cues identified in these scenarios was a function of Soldiers’ working memory, so their recollection of cues was limited by what they could retrieve from memory. If Soldiers did not attend well to the scenarios, or if the scenarios presented a context in which very few cues were salient or memorable, we might expect to find few cues identified as informative. This may have been the case in uncertain scenarios, particularly the Election scenario, which yielded lower numbers of identified informative cues compared to certain scenarios, particularly the Dog Day scenario.

Interestingly, the Election scenario was the only one in which a significant difference in identified cues existed between experienced and inexperienced Soldiers. This scenario also appears to have caused departures from trends in other outcomes as well (see Hypothesis testing, below). This scenario generated the most discussion during debriefing, as Soldiers found it more remarkable than the other scenarios, primarily for being difficult. This scenario included multiple factors ranging from abstract (cultural) to concrete (transport logistics).

Hypothesis testing: Seeking additional information. There was no main effect of scenario on the number of additional details searched by scenario, either collapsed within levels of certainty, $t(58) = .130$, $p = .90$, $d = 0.02$, or treating scenarios independently, $F(3, 159) = .418$, $p = .74$, *partial* $eta^2 = .008$. There was also no main effect of experience on the number of details searched, $F(1, 53) = .028$, $p = .87$, *partial* $eta^2 = .001$. There was no interaction of experience and scenario on the number of details searched, whether scenarios were collapsed within levels of certainty, $F(1, 57) = 0.057$, $p = .81$, *partial* $eta^2 = .001$, or treated independently, $F(3, 159) = 0.549$, $p = .65$, *partial* $eta^2 = .010$. See Table 3 for the descriptive data on the number of searches per scenario.

[5] Soldiers were allowed to take notes while reading through each scenario, but it is unclear whether these notes influenced the number of cues identified as informative. These notes are available for analysis; however, because note taking was not systematic (i.e., formal instruction was not given on how to take notes, nor was note-taking monitored), they have not been coded.

Table 3

Mean Number of Information Searches Per Scenario

	Experience Level					
	Inexperienced		Experienced		Total	
Scenario	Mean	SD	Mean	SD	Mean	SD
Dog Day	1.36	1.29	1.50	1.48	1.44	1.39
The Rock	1.72	1.43	1.63	1.51	1.67	1.47
Checkpoint	1.44	1.45	1.62	1.49	1.54	1.46
Election	1.80	1.38	1.48	1.39	1.61	1.39
Across Scenarios	1.58	1.39	1.56	1.47	1.57	1.43

One possible reason Soldiers conducted so few searches is that each search cost the participant $5 (virtual dollars). Soldiers were told that they needed to complete ten scenarios, thus they had to conserve money. If a Soldier calculated the amount of money required to complete the study, this calculation would reveal that an average of two details per scenario could be searched. Moreover, Soldiers were instructed that some scenarios would be quite difficult, thus perhaps requiring more money. The mean number of searches observed across scenarios (M = 1.57) might support the notion that Soldiers took these factors (limited resources and anticipating conserving money for future scenarios) into consideration. Thus, they restricted their searches only to items that appeared to be relevant and useful.

Relevance of information searched. As noted in the section on manipulation checks, both experienced and inexperienced Soldiers tended to select relevant details (M = .80, SD = .45) more often than irrelevant details (M = .50, SD = .38), $t(54) = 3.95$, $p < .001$, d = .82. Proportion scores were calculated to determine the ratio of relevant to irrelevant details searched. These proportion scores were then used as outcome variables to analyze the effects of experience and scenario on selection of relevant details.

There was no effect of experience on selecting relevant versus irrelevant details ($M_{Experienced}$ = .72 vs. $M_{Inexperienced}$ = .77), $F(1, 13) = .337$, p = .57, *partial eta*^{2} = .025. There was also no effect of scenario on selecting relevant versus irrelevant details, $F(3, 39) = .165$, p = .92, *partial eta*^{2} = .012. There was no interaction of experience and scenario on selecting relevant versus irrelevant details, $F(3, 39) = .302$, p = .82, *partial eta*^{2} = .023. A constrained sample may have limited these particular analyses. If a Soldier did not search any details in one scenario, Soldiers who did not search any details in one or more scenarios were excluded from this analysis. Five experienced and nine inexperienced Soldiers opted not to search any details in at least one scenario. This restricted sample may have limited the power in this analysis. To overcome data lost in this analysis, we conducted pairwise comparisons based on experience for each scenario. For example, a Soldier who refrained from searching details on The Rock scenario, but searched details on the Checkpoint scenario, was excluded from the previous ANOVA, but was included in a between-subjects analysis of the Checkpoint scenario. These analyses also yielded no differences (no $t > 1.09$, no $p < .283$).

Again, the cost structure imposed on Soldiers in these tasks may have influenced their information searching. Because resources were limited, Soldiers may have realized that they could search only one or two items per scenario, and thus, regardless of their experience level, they were compelled to search only those items that seemed to be the most relevant. A lack of difference by experience level and scenario may also have been a result of the way in which additional details were constructed and labeled. Items may have been obviously relevant or irrelevant leading to ceiling effects for selecting relevant items and floor effects for selecting irrelevant items. Despite this possibility, Soldiers appeared to evaluate the scenarios critically enough to compel them to search information that they thought should be relevant to their decisions.

Confirmation bias: Association between initial threat decisions and new details searched. Some additional details available to Soldiers after reading through each scenario were likely to be similar to details associated with identified priority threats. To understand these associations, we matched initial threat decisions to the details searched after reading the scenarios. These data were analyzed using chi-square (Table 4).

Scenarios. In the Dog Day scenario, experienced and inexperienced Soldiers were equally likely to confirm their initial threat hypotheses by searching through added details that matched the topic of their identified priority threat, χ^2 (1, 59) = .355, p = .55. In The Rock scenario, experienced and inexperienced Soldiers were equally likely to confirm their initial hypotheses, χ^2 (1, 57) = 1.436, p = .23. In the Checkpoint scenario, again, experienced and inexperienced Soldiers were equally likely to confirm their initial threat hypotheses by searching through added details that matched the topic of their identified priority threat, χ^2 (1, 59) = 0.213, p = .64. In the Election scenario, experienced Soldiers and inexperienced Soldiers were equally likely to confirm their initial hypotheses, though this difference reached marginal significance, χ^2 (1, 59) = 3.276, p = .07.

Table 4

Percentage of Soldiers Whose Searches Matched Their Initial Threat Decision

	Experienced			
Scenario	Inexperienced	Experienced	χ^2	p
Dog Day	12	21	0.355	0.55
The Rock	20	34	1.436	0.23
Checkpoint	24	29	0.213	0.64
Election	24	47	3.276	0.07
Across Scenarios	20	32.75		

Although no individual chi-square value reached statistical significance, experienced Soldiers ostensibly tended to search information that matched their initial hypotheses more often than did inexperienced Soldiers. To test this trend further, we calculated a likelihood score and analyzed it for all Soldiers. The dichotomous variable representing confirmation ("yes" if a Soldier searched a matching term vs. "no" if a Soldier did not search a matching term) was transformed into a proportion score (number of confirmations/number of scenarios). These

proportions were then analyzed with an independent samples t-test which revealed that, across all scenarios, experienced Soldiers tended to be more likely than inexperienced Soldiers to search details that matched their initial threat decisions (M = .31, SD = .22 vs. M = .20, SD = .22), $t(57)$ = 2.06, p = .04, d = .50. When collapsed within level of certainty, there was no main effect of 'certainty' on confirmation likelihood, $t(56)$ = 1.56, p = .13, d = 0.29. There was no interaction of experience and certainty on confirmation likelihood, $F(1, 55)$ = 0.06, p = .82, *partial* eta^2 = .001.

While it is possible that experienced Soldiers did engage in confirmation bias, there is one alternative explanation. Experienced Soldiers may have generated initial hypotheses that contained information similar to the additional details presented, thus they could only search similar information. Perhaps their hypotheses were more relevant and more readily testable against the available relevant details. Examining initial confidence levels might clarify these two explanations. For example, if experienced Soldiers were demonstrating confirmation bias, we might expect confidence in their initial hypotheses to be higher than that of inexperienced Soldiers who appeared to engage in confirmation bias to a lesser extent.

Initial confidence. Initial confidence ratings were analyzed using a repeated measures ANOVA with experience as the between-subjects factor and scenario as the within-subjects factor. These ratings failed to pass Mauchly's test of sphericity[6], *Mauchly's* χ^2 (5) = 12.173, p = .033; therefore, subsequent F statistics are reported using the Huynh-Feldt correction (*Greenhouse-Geisser Epsilon* > .775). Experienced and inexperienced Soldiers did not differ in confidence ratings ($M_{Experienced}$ = 86.94, SD = 13.70 vs. $M_{Inexperienced}$ = 82.27, SD = 15.31), $t(51)$ = 1.17, p = .248. There was no main effect of scenario on initial confidence $F(2.79, 142.37)$ = 0.736, p = .52, *partial* eta^2 = .014. When collapsed within level of certainty, there was a main effect of scenario certainty on initial confidence. Initial confidence was greater in certain scenarios (M = 86.1, SD = 14.6) than in uncertain scenarios (M = 81.6, SD = 17.3), $t(55)$ = 2.563, p = .01, d = 0.28. There was no observed interaction between experience and scenario on confidence, *Greenhouse-Geisser corrected* $F(2.79, 142.37)$ = 1.00, p = .39, *partial* eta^2 = .019.

Overall, both experienced and inexperienced Soldiers tended to report relatively high confidence in their initial threat decisions. This is not surprising considering they were rating their own hypotheses, not hypotheses generated by others (Adsit & London, 1997). It would be unlikely that Soldiers would report a hypothesis in which they had little confidence. This notion is supported by memory research demonstrating that people tend to withhold information when the accuracy of the information is questionable and their confidence is low (Koriat & Goldsmith, 1994). When potentially unreliable information is withheld, reports become more informative. In this experiment, Soldiers may have been seeking to maximize the information revealed in their hypotheses. They also appeared to evaluate these scenarios critically and this perhaps resulted in a judgment of learning (Koriat, 1997) in which the process of reading and hearing the scenario provided a sense of having learned the critical features of the scenario which translated into confidence in recalling and reporting those critical features. The previous results indicating that certain scenarios tended to yield more identified threats and informative cues than did uncertain scenarios supports this notion. If the ability to report more items increased a sense of

[6] See Field (2005) for Mauchly's test of sphericity and the Huynh-Feldt correction.

fluency for the certain scenarios, then it would be reasonable to expect that confidence would inflate for these scenarios.

Change in hypothesis. Soldiers changed their hypotheses by adding information that altered the initial hypothesis (e.g., the priority threat was changed from IEDs to spies) or extended the initial hypothesis. Overall, very few changes in hypotheses occurred (17% [*n* = 41] of all hypotheses changed). Multiple logistic regression analyses were conducted to predict a change in hypothesis using experience and initial confidence as predictors. In the Dog Day scenario, the regression was not statistically significant, χ^2 (3) = 6.13, *p* = .11, indicating that none of the predictors had a significant effect on changes in hypothesis. However, initial confidence was a marginally significant predictor of change in hypothesis with a *Wald* statistic[7] of 2.74, *p* = .10; no other *p* values < .703. Changes in hypothesis tended to occur more frequently with lower initial confidence ratings.

In The Rock scenario, the regression was statistically significant, χ^2 (3) = 11.22, *p* = .01. All predictors reached statistical significance: confidence attained a *Wald* statistic of 5.25, *p* = .02; experience attained a *Wald* statistic of 4.74, *p* = .03; and the interaction of initial confidence and experience attained a *Wald* statistic of 4.74, *p* = .03. Inexperienced Soldiers who changed their hypotheses had the same confidence levels as those who did not change their hypotheses. In contrast, experienced Soldiers who changed their hypotheses tended to report lower initial confidence ratings. The interaction is presented in Figure 5.

In the Checkpoint scenario, the regression was not statistically significant, χ^2 (3) = 1.66, *p* = .65. No variables predicted change in hypothesis, no *p* values < .578.

In the Election scenario, the regression was statistically significant, χ^2 (3) = 9.78, *p* = .02. Initial confidence was the closest to statistical significance with a *Wald* statistic of 2.47, *p* = .12, thus formally not significant. Similar to the trend in the Dog Day scenario, changes in hypothesis tended to occur more frequently with lower initial confidence ratings.

Changes in hypotheses did not occur frequently, despite Soldiers having access to additional information. Soldiers may have refrained from changing their hypotheses because they placed greater weight on the initial set of cues compared to later information. This may have resulted in a cue primacy effect (Adelman, Bresnick, Black, Marvin, & Sak, 1996). Simply reporting the initial cues, which were informative, may have increased the salience of these cues during later evaluation of the information. Future research that includes a protocol in which participants do not report initially informative cues explicitly might help elucidate this primacy effect. It may be informative to study the primacy effect in a real-world threat detection context, as it suggests that making informative cues explicitly salient may lead to a bias against evaluating any novel information and incorporating it into a revised hypothesis.

[7] See Field (2005) and or Menard (2002) for information on Logistic Regression, including the *Wald statistic.*

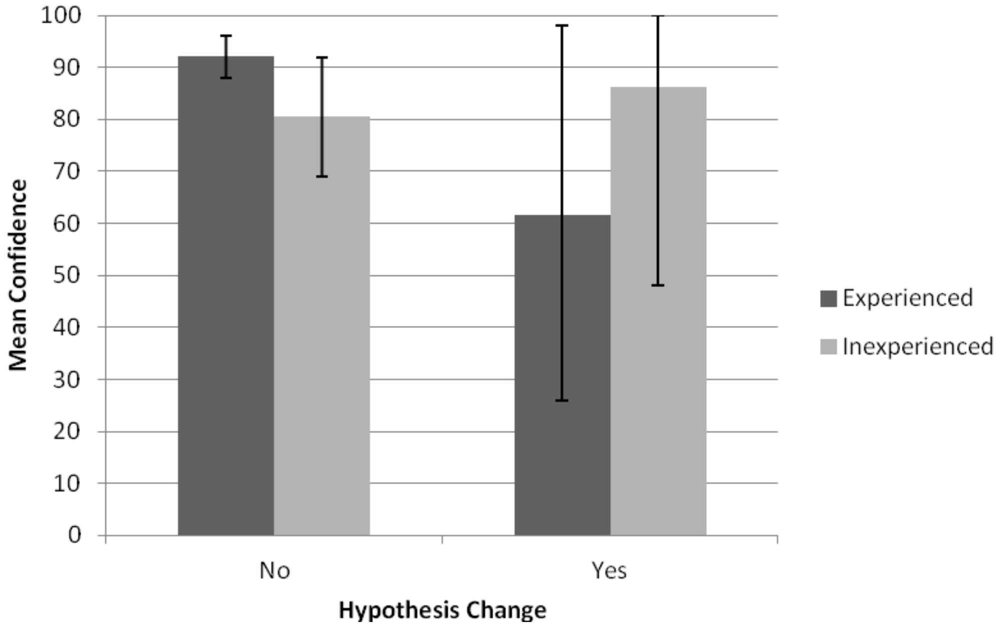

Figure 5. Interaction between initial confidence and experience on hypothesis change in The Rock scenario.
Note: Error bars represent 95% CI.

Overall, changes in hypotheses appear to be associated with lower initial confidence ratings. This indicates that Soldiers may have been relatively well calibrated (their confidence and accuracy were closely related). Soldiers recognized that their initial hypotheses may have been suboptimal in some way, and confirmed this during their search through additional information. Thus, they changed their hypothesis to reflect their new knowledge of the situation. Interestingly, in The Rock scenario, inexperienced Soldiers appeared poorly calibrated. Those who changed their hypothesis tended to be more confident in their initial hypotheses than were inexperienced Soldiers who did not change their hypotheses. These results should be evaluated with caution. Observed changes in hypothesis were not always wholesale changes, instead additions to and subtractions from hypotheses were scored as changes. Thus, Soldiers may have been confident in their initial hypothesis. They may have added a detail after searching through the additional information that did not substantively change the hypothesis, and remained confident in that initial hypothesis.

Conclusion and Future Research

A few trends worth further consideration emerged from this experiment. Experienced and inexperienced Soldiers focused on different priority threats across three of the four scenarios, though their overall patterns of responding did not differ. This might indicate that Soldiers who previously deployed, and went outside the wire, attend to different cues in the environment and possibly process these cues differently. Supporting this notion, experienced Soldiers were likely to report more discrete threats when identifying their priority threat in each scenario. They were also more likely to search information that confirmed their initial hypotheses. The finding that

Soldiers' initial confidence seemed to be associated with their inclination to change their hypotheses is promising, particularly if they are inclined to evaluate and revise hypotheses when they are not maximally confident. Whether or not Soldiers changed their initial hypotheses is a reasonable measure of how plausible they thought their hypotheses were, especially given the opportunity to evaluate them critically. However, future research should incorporate a more direct measure of the confidence-accuracy relationship and do so in the type of ill-structured decision environment we used. Traditional calibration studies utilize known solutions (at least in terms of using probabilistically derived task environments), which begets only a finite set of responses upon which calibration can be assessed. However, the operational environment is marked by dynamic uncertainty. As such, the solutions are often subjective judgments based on subjective cue utilization in a fluid task environment with shifting instruction sets and potential outcomes. As noted by Shanteau (1989), trying to understand experts or the development of expertise requires an understanding, by the researcher, that experts often work on tasks that do not always have correct answers.

Experienced and inexperienced Soldiers did not differ on other measures, such as the variability in their priority threats, the number of cues identified as informative, and whether they searched relevant additional information topics. Perhaps these results reflect the constraint imposed by the testing materials, such as a limited number of cues available to inform the initial hypothesis; however, they may also reflect general trends in cognition. Across scenarios, there was little difference between experienced and inexperienced Soldiers in identifying informative cues (means of 1.7 and 1.9 for inexperienced and experienced Soldiers, respectively). This finding comports with literature that suggests decision makers generate hypotheses using relatively small sets of data (e.g., Klein, 1998). Experience did not influence the relevance of information searched; moreover, Soldiers tended to search relevant details more often than irrelevant details. As with the association between initial confidence and changes in hypotheses, this finding is promising, as it indicates that Soldiers are evaluating their hypothesis based on information widely considered as relevant. Future research might extend beyond evaluating threat detection and assessment to include action choices, for instance, through more interactive testing in which participants can decide on and implement a COA. As an example, future research could extend these findings to determine if the information Soldiers deem relevant has any influence on successful courses of action as well as the subsequent consequences and further choices.

Overall, this experiment supports the idea that differences exist between novice and experienced Soldiers' decision processes, particularly in operationally relevant domains. We did not find that inexperienced Soldiers would base their hypotheses on a wider range of cues than that used by experienced Soldiers. We also failed to observe differences in initial confidence levels associated with hypothesis generation and the extent to which Soldiers seek additional and relevant information. However, we discovered that (deployment) experience influences Soldiers' tendency to confirm their hypotheses and that initial confidence might be a factor that influences changes in hypotheses. Future research should allow testing in naturalistic environments to gain a greater understanding of Soldier decision processes. This might mitigate limitations of memory inherent in computer-based tests, where participants only passively experience the scenario through text rather than a comprehensive experience. For example, live scenarios could provide a larger, richer set of cues available for informing initial hypotheses.

The formation and testing of hypotheses is very much about determining potential causes given available cues. In this research, we examined the relationship between initial confidence, hypothesis generation and information search as well as the influence of the certainty of information on assessment of potentially threatening situations. As such, the focus of the analysis was on the decision outcomes or products rather than necessarily on the external or internal factors that could influence cognitive processing. Future research could involve exploring the factors that affect the formation of causal links, such as those outlined by Einhorn and Hogarth (1982), including contiguity of space, similarity, and temporal order of events within a decision environment. Likewise, elements of predisposition for decision-making, such as decision- making style or approach to problems (see Driver, 1979; Scott & Bruce, 1985) could assist in determining the amount of information persons search before a decision is reached and, as a result, assist in determining the primary source of information upon which hypotheses were generated and the decisions were made.

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Appendix A

Scenarios and Questions

Dog Day

You are assigned to Bravo Co, 1/5 Cavalry 2nd Platoon. Your Platoon is assigned to an area that has seen a recent upswing in violence from both the Taliban and growing anger at the U.S. from perceived insults against the Islamic religion and the Qur'an. Recent Intel indicates that the locals have held several meetings where members discussed ways to retaliate against the U.S. You and your Afghanistan Army counterparts have conducted daily patrols in your sector and have experienced an increase in hostility, but have not experienced an increase in violence. During a recent patrol, you arrested several locals after a search of their vehicle uncovered several components for an IED. During questioning, one detainee claimed that several IEDs are hidden in the village, but he would not provide any more information.

Your S-2 was able to provide the following information from the previous unit in the area. Working with the locals in the area for the last year, the previous unit seemed to be winning the hearts and minds of the people. They worked together to bring a potable water source to the village and they formed a neighborhood watch made up of the local civilian population who inform the unit of anything disturbing the peace in the area. They founded a school and helped deliver school supplies. The population seemed very pleased with this progress. Several months ago, new faces started appearing in the area and the local people became less friendly and more anti-U.S. in their attitudes. Two months before your unit took over the mission in the area, the other unit killed four of the newcomers while they were attempting to emplace an IED. The four people killed were Pakistani and had links to the Taliban. Intel indicates that the Taliban have a new cleric in the area who is inflaming anti-U.S. tensions with the local population. The former unit was unable to identify or locate the cleric. Prior to the arrival of the new residents and the cleric, overall violence in the area was declining and the previous unit had made great progress toward turning the area over to the Afghan forces on schedule. You suspect that some of the detainees are newcomers who have been disturbing the peace but no one has yet been able to confirm this.

You are now out on patrol with trained dogs looking for the IEDs and IED components. After several searches of the area, the dogs keep returning to the same location. However, you do not see anything unusual or out of place in that location. The suspicious location is in front of a house where one of the detainees said he lives. The street you are on is usually full of activity. Today the street is relatively quiet. Two women are doing laundry in front of the detainee's house and several men are about a block away, doing mechanical work on a pickup truck.

Instructions: You will now answer a series of questions about this scenario. First, you will describe the highest priority threat in this scenario and explain why this threat is important. Next, you will answer questions concerning your confidence and the cues you used to make your assessment. Following this, you will have the opportunity to search for more information about this situation. You will be required to explore at least one piece of information per scenario.

Remember, each piece of information you gather costs you money. You need enough money to get through all 10 scenarios, so review only as much information as you think you need to make a good assessment of the threat. Finally, you will have the opportunity to revise or add to your original assessment, if you choose to.

1. Describe the highest priority threat in this scenario and explain why this threat is important.
    a. Please indicate how confident you are that this threat takes the highest priority. Provide a percentage from 0% (no confidence) to 100% (absolute confidence).
    b. List the information or cues you focused on to identify this threat.

2. What course of action would you take to deal with this threat?
    a. What outcome do you expect by taking this course of action?
    b. Please indicate how confident you are that this course of action will result in the anticipated outcome. Provide a percentage from 0% (no confidence) to 100% (absolute confidence).

Click on any of the topics below to gather more information. You must select at least one topic.

- **Previous threat activity in the area:** In this region, Soldiers have discovered that the locals often bury bomb-making materials until needed. (relevant)*
- **The detainee's house:** The detainee's house is located behind a large wall. An old wheelbarrow sits out front. The detainee's uncle owns this house; villagers have indicated that this uncle is close with the new cleric in the area. (relevant)
- **The women doing laundry:** The women have been tending to their laundry for approximately 30 minutes. They have been talking and laughing quietly, and are not paying much attention to the Soldiers' activities (irrelevant)
- **Typical street activity:** This street is one of many that lead to a popular market. Foot and vehicle traffic tend to be light except during key travel times to the market. (irrelevant)
- **The IED components found in the vehicle:** The components for the IEDs are from Pakistan. Soldiers found many of the same key components for IEDs, but these did not include all the components necessary to complete construction of an IED (relevant)
- **Scheduled turnover to Afghan Forces:** The previous unit worked hard to prepare the area for an on-time turnover to Afghan Forces, but the recent tension has increased doubt that the turnover will happen as scheduled. (irrelevant)

**These labels are provided for the reader, but were not revealed to participants.*

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3. Describe the highest priority threat in this scenario and explain why this threat is important. If there are no changes to your initial response, just type, "No Change."

4. What are some alternative explanations for the information and cues you focused on to make your threat assessment (for example, a man could be red in the face because he has been exerting himself or because he is embarrassed)?

5. In addition to your initial course of action choice, what other actions might work to reduce or eliminate this threat?

The Rock

You are assigned to Bravo Co, 1/5 Cavalry 2nd Platoon. You have been working with the Afghan Army in a nearby sector for months and have achieved great progress in training the Afghan Army to take over the sector when you leave. Last night, the Afghan Army in this sector was attacked by a large number of Taliban on a hit and run mission just outside the Afghan/U.S. base. During the attack, four Afghan Soldiers and several Taliban were killed, along with three local civilians. One U.S. Soldier was wounded. The wounded U.S. Soldier reported that a large protest was going on outside the compound and the gunmen emerged from the crowd, surprising the guards on duty at the base. Your Platoon was called in to patrol the streets and find the Taliban terrorists.

The S-2 reports that approximately 30 gunmen carrying small arms, sniper rifles and RPGs carried out the attack. The gunmen may have incited frenzy among the protestors so they could attack the Afghan Army and escape amid the chaos. The gunmen seemed to know response procedures and the number and positions of personnel guarding the compound, so someone in the Afghan forces may have supported this attack. The speed at which the gunmen carried out their attack suggests that they have extensive training in tactics. One of the gunmen killed was the brother of an Afghan Soldier working inside the compound. One of the bystanders killed was the son of the village chief. S-2 suspects that the gunmen have a large weapon cache somewhere in the area. Your ROE states that you are authorized to use deadly force to protect yourselves, your unit, or U.S. allies. You should suspect and apprehend all military age personnel ages 15 to 50 and bring them to the compound for eyewitness identification and questioning. You are to search all buildings and structures for the weapon cache or plans used for the attack. You will begin by searching a row of buildings owned by a village merchant who may have some family members in the Afghan Army.

Instructions: You will now answer a series of questions about this scenario. First, you will describe the highest priority threat in this scenario and explain why this threat is important. Next, you will answer questions concerning your confidence and the cues you used to make your assessment. Following this, you will have the opportunity to search for more information about this situation. You will be required to explore at least one piece of information per scenario. Remember, each piece of information you gather costs you money. You need enough money to get through all 10 scenarios, so review only as much information as you think you need to make a good assessment of the threat. Finally, you will have the opportunity to revise or add to your original assessment, if you choose to.

1. Describe the highest priority threat in this scenario and explain why this threat is important.
   a. Please indicate how confident you are that this threat takes the highest priority. Provide a percentage from 0% (no confidence) to 100% (absolute confidence).
   b. List the information or cues you focused on to identify this threat.

2. What course of action would you take to deal with this threat?
   a. What outcome do you expect by taking this course of action?

b. Please indicate how confident you are that this course of action will result in the anticipated outcome. Provide a percentage from 0% (no confidence) to 100% (absolute confidence).

Click on any of the topics below to gather more information. You must select at least one topic.

- **Known connections between Afghan Soldiers and attackers**: In addition to the brother of an Afghan Soldier, two of the gunmen killed went to the same school as one of the Afghan Soldiers killed in the attack. (relevant)
- **Location where the Afghan Soldiers were killed**: The four Afghan Soldiers were killed near the front gate to the base. (irrelevant)
- **Possible locations of the gun cache**: Within the past two months, Soldiers swept several buildings in the area for weapons and found caches of small arms. Intel indicates a merchant who has business dealings with the Taliban owns these buildings. (relevant)
- **Background on the son of the village chief**: The son of the village chief was a 16-year old student who worked alongside his father to improve living conditions in the village. He was active in anti-Taliban efforts in the community. (irrelevant)
- **The reason for the protest**: Villagers were protesting American use of drones in the area. (relevant)
- **The number of military age men in the village**: There are approximately 120-130 military age men in this village. (irrelevant)

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3. Describe the highest priority threat in this scenario and explain why this threat is important. If there are no changes to your initial response, just type, “No Change.”

4. What are some alternative explanations for the information and cues you focused on to make your threat assessment (for example, a man could be red in the face because he has been exerting himself or because he is embarrassed)?

5. In addition to your initial course of action choice, what other actions might work to reduce or eliminate this threat?

Checkpoint

You are the Platoon leader of 2nd platoon, B Co 1/7 Cav. and you have just been assigned to this area. The outgoing unit briefed you on the area, letting you know that violence is generally low in this large farming community. Any violence that occurs tends to come from outside the sector. The previous unit kept the violence low by conducting constant patrols at different times of the day and by developing a great relationship with the Elders in the area. The Elders seem to have a strong leadership presence in the community and have established laws amongst themselves, as if a formal government does not exist. While out on patrol, your Bravo section setup a checkpoint to look for Taliban extremists reportedly heading for your sector. The checkpoint is on a road commonly used by local farmers to transport their produce. At this checkpoint, they detained a brother of one of the Elders after he refused a body search, perceiving it as an insult. The Elders refuse to speak with you or any U.S. Soldier until you release the Elder's brother and the U.S. government issues a formal apology. You informed your chain of command about this situation and you are waiting for a response. Tensions in the community are now running high as the lack of communication between your forces and the Elders council has people in the community refusing to speak. You have heard reports that some younger members of the community want to take revenge for the perceived insult. Historically, the Elders have looked down on these types of activities, but without communication, you cannot be sure of their stance in this situation. You have closed the road leading to and from the front of your compound and are searching anyone who could pose a threat to your base.

Intelligence suggests no active military insurgents in this area, mainly because the local laws require swift punishment of insurgent activities. Previous attacks in this sector were tracked to groups coming over the mountains from Pakistan and several potential attacks have been stopped thanks to UAV patrols along the border. Intel indicates that the locals own only small arms, which they use to protect their homes and farms. It is critical for U.S. troops to keep on good terms with the Elder council because the information they provide has been vital to knowing Taliban movement in the area.

Instructions: You will now answer a series of questions about this scenario. First, you will describe the highest priority threat in this scenario and explain why this threat is important. Next, you will answer questions concerning your confidence and the cues you used to make your assessment. Following this, you will have the opportunity to search for more information about this situation. You will be required to explore at least one piece of information per scenario. Remember, each piece of information you gather costs you money. You need enough money to get through all 10 scenarios, so review only as much information as you think you need to make a good assessment of the threat. Finally, you will have the opportunity to revise or add to your original assessment, if you choose to.

1. Describe the highest priority threat in this scenario and explain why this threat is important.
   a. Please indicate how confident you are that this threat takes the highest priority. Provide a percentage from 0% (no confidence) to 100% (absolute confidence).
   b. List the information or cues you focused on to identify this threat.

2. What course of action would you take to deal with this threat?
   a. What outcome do you expect by taking this course of action?
   b. Please indicate how confident you are that this course of action will result in the anticipated outcome. Provide a percentage from 0% (no confidence) to 100% (absolute confidence).

Click on any of the topics below to gather more information. You must select at least one topic.

- **Recent activities of young males in the community:** The younger males in the area have been very vocal about the arrest and have staged several small protests. There are rumors that they have held a series of closed-door meetings without including the Elders. (relevant)
- **Farming conditions:** The weather and time of year are great for harvesting the local grain. More farmers have been delivering goods to the market place in recent weeks. (irrelevant)
- **The Elder's brother:** There is no existing Intel on the brother and he has no known ties to the Taliban. Troops found a small amount of drugs on the brother when they searched him. (relevant)
- **Previous peacekeeping activities:** Troops in the previous unit helped the community build a school and they rebuilt several roads around the market place. (irrelevant)
- **Recent Elder activity:** The Elders recently cancelled a meeting with you and told members of the community to stop working for the U.S., leaving many without a source of income. (relevant)
- **Laws established by the Elders:** The laws established by the Elders aim to keep violence down and maintain order in the community. The Elders impose severe punishment on law-breakers and those who threaten to disrupt the peace in any way. (irrelevant)

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3. Describe the highest priority threat in this scenario and explain why this threat is important. If there are no changes to your initial response, just type, "No Change."

4. What are some alternative explanations for the information and cues you focused on to make your threat assessment (for example, a man could be red in the face because he has been exerting himself or because he is embarrassed)?

5. In addition to your initial course of action choice, what other actions might work to reduce or eliminate this threat?

Election

You are assigned to 3rd Platoon, Bravo Company 1/5 Cav. Your Platoon has been assigned to support the Coalition forces in protecting the civilian population as they gather to cast their vote in the region's first free election. Because the residents in this region openly support the Coalition and free elections, Coalition forces fear that the Taliban and insurgent forces will attempt to disrupt the elections. This area has been free of attacks for several months and the area remains stable, largely because the region's Elders worked extensively with U.S. and Coalition forces to improve conditions and increase employment opportunities in the community. The Elders and community members set up an election headquarters in a building close to the central market and they have been actively promoting the elections through a series of community meetings. The Elders have not received any threats, but they are concerned about security during the elections. Intel sources have investigated and confirmed that no credible threats currently exist. They continue to monitor the situation. The Clerics in this region supported the Coalition until recently and are now withdrawing their support of the elections because they believe that women should not vote, in accordance with the Muslim religion. Community members will have three days to cast their vote at the election headquarters. Your platoon will escort local vehicles that will transport voters to and from their homes. You will also be part of the standing guard rotation at the election headquarters.

Your S-2 has no knowledge of an imminent attack and there are no alerts of immediate danger. According to local informants, some people may wish to disrupt the election process, perhaps by preventing voters from reaching the election site, but it is not clear how they might do that.

Instructions: You will now answer a series of questions about this scenario. First, you will describe the highest priority threat in this scenario and explain why this threat is important. Next, you will answer questions concerning your confidence and the cues you used to make your assessment. Following this, you will have the opportunity to search for more information about this situation. You will be required to explore at least one piece of information per scenario. Remember, each piece of information you gather costs you money. You need enough money to get through all 10 scenarios, so review only as much information as you think you need to make a good assessment of the threat. Finally, you will have the opportunity to revise or add to your original assessment, if you choose to.

1. Describe the highest priority threat in this scenario and explain why this threat is important.
   a. Please indicate how confident you are that this threat takes the highest priority. Provide a percentage from 0% (no confidence) to 100% (absolute confidence).
   b. List the information or cues you focused on to identify this threat.

2. What course of action would you take to deal with this threat?
   a. What outcome do you expect by taking this course of action?
   b. Please indicate how confident you are that this course of action will result in the anticipated outcome. Provide a percentage from 0% (no confidence) to 100% (absolute confidence).

Click on any of the topics below to gather more information. You must select at least one topic.

- **Routes to the election headquarters:** The voter transportation vehicles will pick voters up at several designated meeting places, such as local schools and mosques and drive them through the central market to the headquarters. (relevant)
- **Elders' election promotion activities:** The Elders held a series of publicized meetings to discuss the candidates and issues, and to review voting procedures. (irrelevant)
- **Voter activity around the election headquarters:** The vehicles drop off large numbers of voters at the same time. This causes large crowds to gather around the front door as voters wait to show their identification and go inside. (relevant)
- **Voter transportation vehicles:** Voters will be transported in buses and the backs of pickup trucks to the election headquarters. (irrelevant)
- **Relationship between Clerics and Coalition:** The Clerics have started reaching out to the community to gather support for their position against women voting. They have also ventured outside the immediate community to rally support for their position on women voters. (relevant)
- **Previous use of the election headquarters building:** The election headquarters is located in a building that was used as a storehouse for market merchandise until a larger building was built on the other side of the central market. The building was vacant for several years before the Elders decided to use it for the election. (irrelevant)

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3. Describe the highest priority threat in this scenario and explain why this threat is important. If there are no changes to your initial response, just type, "No Change."

4. What are some alternative explanations for the information and cues you focused on to make your threat assessment (for example, a man could be red in the face because he has been exerting himself or because he is embarrassed)?

5. In addition to your initial course of action choice, what other actions might work to reduce or eliminate this threat?

Appendix B

Demographic Questions

1. Time in service (yrs)

2. Current rank

3. Time in current rank (months)

4. Current MOS

5. Age

6. Have you ever deployed? Yes No

7. If yes, how many times have you deployed?

8. Location of most recent deployment (city or cities and country)

9. MOS while on your most recent deployment

10. How often did you go outside the wire on your most recent deployment?
    - Never
    - Less than once a month
    - Once a month
    - More than once a month
    - Once a week
    - More than once a week
    - Everyday

11. Describe some of your duties during your most recent deployment.

12. Describe any training you have received that improved your ability to detect threats.